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Assessing Students' Problem-Solving Skills in Concrete-Representational-Abstract Approach

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Abstract: This study assessed the problem-solving skills in mathematics through Concrete-Representational-Abstract Approach of the Grade 8 students at San Agustin Institute of Technology of S.Y. 2024-2025. Specifically, the study seeks to: (1) ascertain the level of problem-solving skills of students in mathematics when exposed to CRA and non-CRA in terms of pretest and posttest; and (2) determine if there is a significant difference in students' problem-solving skills in mathematics when exposed to CRA and non-CRA in terms of pretest and posttest. The study utilized a quasi-experimental design that involved two intact sections that were selected at random, one section exposed to CRA approach (n=44) and the other one is exposed to non-CRA approach (n=40). The data were collected using the researcher-made problem-solving questionnaire with an adopted rubric. Results revealed that both students in the CRA and non-CRA group have 'Very Low' level of problem-solving skills. Consequently, after the intervention, the posttest scores showed improvement for both groups. Additionally, the ANCOVA result revealed that CRA approach significantly enhanced problem-solving skills of the students compared to the non-CRA.

Keywords: CRA approach, problem solving skills.

INTRODUCTION

On a global perspective, the emphasis on problem-solving skills and productive disposition in mathematics has gained significant attention due to their critical role in preparing students for complex and real-life challenges. With the increasing demand for 21st-century skills, problem-solving in particular, the ability to effectively address mathematical problems and maintain a productive disposition toward the subject has become one of the concerns to educational reforms worldwide.

Problem-solving is an important skill for learning mathematics. When studying math, mathematical facts and content are important but still insufficient to help students learn and understand complex concepts. Problem-solving is the process of constructing and applying mental representations of problems to find solutions to problems encountered in nearly every context (Jonassen & Hung, 2012). One such definition refers to problem-solving as the process of designing, evaluating, and implementing a strategy to answer an open-ended question or achieve a desired goal (Abdullah, Abidin & Ali, 2015). Problem-solving has been seen as an important aspect of mathematics teaching and learning for a long period of time. Problem solving is an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the literacy domains or curricula areas that might be applicable are not within a single domain of mathematics, science or reading" (OECD, 2003a). Another study stated that solving mathematical problems is essential to the general purpose of learning mathematics; it is prioritized over the process and, as a result, is the focus of school mathematics and aims to help develop mathematical thinking (Novriani & Surya, 2017).

However, students appear to struggle with their schoolwork, particularly in mathematics problem-solving (Tambychik & Meerah, 2010). Many students cannot cope with the basic skills needed in mathematics, so it is difficult for them to solve the problems. Students also reported facing difficulties in making accurate interpretations, memorizing, retrieving facts, maintaining focus, and using their logical thinking (Aziz, Salleh & Tambychik, 2009).

In the context of problem-solving skills, manipulatives offer a significant benefit. These tools help make abstract mathematical concepts more concrete and accessible. Concrete-representational-abstract (CRA) approach is an instructional strategy that utilizes concrete models. However, there were only limited research on CRA implementation in high school mathematics courses like algebra, geometry, trigonometry, and calculus. Bouck and Park (2018) conducted a systematic literature review of studies between 1975 and 2017 on using manipulatives to support students with LDs; 29 articles explored using manipulatives through the CRA approach. Of those 29 articles, 5 were identified as targeting secondary mathematics students (Strickland & Maccini, 2012; Cass, Cates, Smith & Jackson, 2003; Maccini & Hughes, 2000; Maccini, & Ruhl, 2000; & Scheuermann, Deshler & Schumaker, 2009), four (4) of which found that all students

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increased their mathematical knowledge, skills, or both. Maccini and Hughes (2000) found that five of the six student participants improved on all mathematical tasks. This small set of studies presents a promising approach to teaching mathematics to high school students with LDs and requires further investigation (Maccini and Hughes, 2000).

The CRA approach exposes students through three stages of learning, which is concrete, representation, and abstract. Teaching with CRA involves a three-stage learning process that helps students to understand mathematical concepts through the physical manipulation of concrete objects, followed by learning through pictorial representation of concrete object manipulations, and ends by solving mathematical problems using abstract notation. The sequence (CRA) has an effective instructional sequence on mathematical concepts for students (Ahlam & Gaber, 2014).

Henceforth, this was conducted at San Agustin Institute of Technology (SAIT) since the students have undergone massive changes in their personality towards learning and study habits. Additionally, some teachers have reported and complained that they had difficulty teaching their students in mathematics since they were exposed to modular classes in their previous years, and most of them learned less from the modules, particularly the grade 8 students. Moreover, most of them own cellular phones that causes distractions and easily distracted by peers during classroom instruction and discussion. These information motivated the researcher to conduct the study to assess students' problem solving skills in mathematics using Concrete-Representational-Abstract (CRA) approach compared to traditional learning of the grade 8 students in SAIT.

MATERIALS AND METHODS

This study employed a quai-experimental research design. It involved two (2) intact sections that were selected as respondents of the study with 44 students in the CRA group and 40 students in the non-CRA group. Particularly from grade 8 junior high school students of San Agustin Institute of Technology (SAIT) for SY 2024-2025, since they are typically 13-14 years old and at a developmental stage where their cognitive abilities are advancing. The grade 8 students are transitioning from concrete operational thinking (focused on here-and-now) to more abstract, formal operational thinking (which involves logic, reasoning, and hypothetical thinking). This stage offers an ideal moment to assess students' problem-solving abilities and prepare them for more advanced challenges.

The researcher conducted the study during the third grading period for SY 2024 – 2025. Before the start of the study, the researcher administered a pre-test before implementing the strategy into action to evaluate the student's problem solving skills. At the end of the third grading period, students took the same test that served as a posttest and answered the same questionnaire. The obtained data was categorized, tabulated, and summarized. The researcher uses descriptive statistics such as mean, standard deviation, and percentage to describe the level of students' problem solving skills.

In this study the researcher used a researcher-made problem solving test that has been evaluated by group of experts for validation. The test consists of five (5) questions about the concept of geometry that includes four (4) indicators of problem solving skills. Indicators of problem solving skills adopted from G Polya: (1) Understanding Problems, (2) Designing plans, (3) Implementing plans, (4) Looking Back (Hidayat, *et al*., 2017). The rubric of problem solving skills assessment was adapted by Hidayat with the score used was 1 to 5 (Pamungkas, *et al*., 2019).

RESULTS AND DISCUSSION

Level of Problem-Solving Skills. Table 1 shows the mean and qualitative interpretation of the gathered data on the students' level of problem solving skills in mathematics of those students exposed to CRA and those exposed to non-CRA in the pretest and posttest in the CRA and non-CRA group.

The pretest data results for both groups are 12.52 and 10.88, respectively, as can be seen. The results show that most of the students in the two groups scored below 75% (Very Low), with 100 percent in both the CRA and non-CRA groups. No students in any group obtained a score of 75%-79% (Low), 80%-84% (Moderate), 85%-89% (Good), or 90%-100% (Very Good).

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Table 1: Level of students' problem solving skills before and after the intervention

Raw Score	Percent Equivalent	CRA				Non-CRA			
		Pretest		Posttest		Pretest		Posttest	
		N	%	N	%	N	%	N	%
24 – 25	90 - 100	0	0	0	0	0	0	0	0
22 – 23	85 – 89	0	0	0	0	0	0	0	0
20 – 21	80 – 84	0	0	1	2.27	0	0	3	7.5
18 – 19	75 – 79	0	0	16	36.36	0	0	1	2.5
0 – 17	Below 75	44	100	27	61	40	100	6	90
TOTAL		44	100	44	100	40	100	40	100
Overall		12.52		16.39		10.88		12.98	
MPS		Very Low		Very Low		Very Low		Very Low	

Legend:

Raw Score	Grade Scale	Qualitative Interpretation
24 – 25	90 - 100	Very High
22 – 23	85 – 89	High
20 – 21	80 – 84	Moderate
18 – 19	75 – 79	Low
0 – 17	Below 75	Very Low

After implementing the intervention using the concrete-representational-abstract approach, there was a notable improvement in the problem-solving skills of grade 8 students, as indicated by the data results. Learners taught using a concrete-representational-abstract approach had an average problem-solving score of 16.39. In contrast, learners taught using a non-collaborative problem-based learning approach had an average score of 12.98.

Moreover, when examining the individual results of the learners in the concrete-representational-abstract approach group, it becomes apparent that there was a range of outcomes across different percentage categories. The students demonstrated 2.27% in 'moderate' level of problem-solving skills, 36.36% showed a 'low' level, and 61% exhibited a 'very low' level. This demonstrates the effectiveness of CRA in elevating problem-solving skills to a level beyond baseline performance.

Furthermore, the data reveals that both the students in the CRA and non-CRA achieved a mean percentage score below 75%, indicating a "very low" level of problem-solving skills. Meanwhile, individual results of students in the non-CRA showed 7.5% in 'moderate' level, 2.5% in 'low' level, and 90% in the 'very low' level. However, when comparing the two groups, the CRA class obtained a higher mean percentage score compared to the non-CRA class, with a mean percentage score of 16. 39 and 12.98, respectively.

Despite the overall improvement, 61% of students in the CRA group and 90% in the non-CRA group remained within the below 75% demonstrated a "Very Low" level of problem-solving skills. Based on the results, this implies that the instructional strategy employed had a positive impact on the students' mathematical abilities. This means that when compared to conventional methods of teaching, the CRA approach improves the students' level of problem-solving skills.

This implies the ongoing challenges in advancing mathematical proficiency to higher levels. Abdullah, *et al*. (2015) attribute difficulties in problem-solving to weak conceptual foundations and limited ability to abstract mathematical patterns from word problems. The CRA approach partially addresses these barriers but requires sustained and iterative reinforcement to further improve performance, especially for students with significant foundational gaps.

The observed improvement also confirms the findings of Siegler and Lortie-Forgues (2015), who emphasize that problem-solving ability enhances when students are provided with structured learning experiences. Additionally, according to the research of Schoenfeld (2016) asserting that students develop better problem-solving skills when exposed to instructional methods that emphasize conceptual understanding rather than rote memorization. Moreover, research conducted by Fauziah (2014) states that students' mathematical problem-solving abilities in cube and block material can be improved more optimally by using a modified CRA approach compared to conventional learning.

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The result of this study supports the claim of previous research that students who are identified to have learning mathematics difficulty learn better when CRA approach is used since the test result shows that the students of the control group, the one who uses the CRA approach, has higher test result (Flores, Hinton, Stroizer & Terry, 2014). It is in line with the study of Putri (2015) which concludes that the implementation of CRA approach in mathematics learning can enhance the ability of mathematical representation and spatial sense.

This aligns with the principles of the Concrete-Representational-Abstract (CRA) approach, which supports gradual conceptual learning and skill acquisition in mathematics (Witzel & Kiuhara, 2017). Accordingly, this shows that using the CRA approach in learning can improve students' problem-solving skills (Citra, *et al*., 2019). The CRA approach allows students to digest concepts more meaningfully and contextually (Flores & Hinton, 2022).

Analysis of Covariance (ANCOVA) of Students' Problem Solving skills in mathematics before and after the intervention in terms of posttest. The result of the posttest scores of the two groups was presented in the table using analysis of covariance (ANCOVA). The results indicated a statistically significant difference between the post-test scores of CRA and non-CRA groups, with an F-value of 17.688 and a probability value of 0.000 ($p<0.05$). This means that there is highly significant difference in the mathematics problem solving skills of the students exposed to CRA and non-CRA approach.

Table 2: Comparison of problem solving skills in mathematics of those students exposed to CRA and those exposed to non-CRA in terms of posttest

GROUP	Mean	Std. Deviation	N
CRA	16.39	2.264	44
NON CRA	12.98	2.851	40
Total	14.76	3.068	84

Source	SS	df	MS	F-value	Sig
Group	94.838	1	94.838	17.688	0.000**
Pretest (Covariate)	103.112	1	103.112	19.231	0.000
Error	434.295	81	5.362		
Total	19086.000	84			

Note: **- highly significant at 0.05 level

The table also shows the problem-solving skills of the students in the CRA and non-CRA group in terms of posttest. The posttest mean score of the students in the CRA group was 16.39 and a standard deviation of 2.264. On the other hand, the students in the non-CRA group have a posttest mean score of 12.98 and a standard deviation of 2.851. this implies that students taught using the CRA approach significantly outperformed those in the non-CRA group in the posttest of mathematical problem-solving.

These findings strongly suggest that the CRA approach is a more effective instructional strategy for improving problem-solving skills in mathematics. By guiding students through concrete experiences and representational models before transitioning to abstract problem-solving, the CRA method facilitated deeper conceptual understanding, which translated into higher post-test performance. As a matter of fact, the study Witzel, Riccomini, and Schneider (2008) demonstrated that students taught through CRA performed better on complex word problems and retained information longer.

Moreover, students are more engaged and motivated when they use manipulatives to explore concepts. They can participate in mathematical discourse, share their thinking, and reflect on their learning. This leads to increased achievement and a deeper understanding of the concepts studied (NCTM, 2010). Hence, CRA provides an opportunity for increased interaction with content and increased frequency of response for all students (Witzel, 2005).

Through mathematical reasoning, students can enhance their problem-solving skills, construct proofs, and draw conclusions (Kotto, *et al*., 2022). This research aligns with the findings of Zulfakri, *et al*. (2019), which indicate that the CRA approach leads to better improvements in students' mathematical representation and problem-solving abilities compared to conventional teaching methods. Furthermore, researchers have shown

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that the use of the CRA sequence of instruction has been very effective and beneficial to learners who struggle with understanding mathematical concepts and procedures performance (Flores, 2009; Putri, 2015; Salingay & Tan, 2018).

CONCLUSION AND RECOMMENDATION

The Grade 8 students who were exposed to CRA approach and exposed to non-CRA approach both demonstrated a very low level of problem-solving skills prior to the intervention. Although there's a numerical improvement, the category didn't change which means the improvement might not be substantial in terms of mastery level.

Moreover, there is a greater level of improvement in their problem-solving skills in mathematics. The ANCOVA result revealed that there is a highly significant difference in the level of problem solving skills of students exposed to CRA and those exposed to non-CRA. The CRA group have higher posttest scores and greater increase in mean scores, which implies that the CRA approach is more effective in enhancing problem solving skills. Although both groups showed improvement, the findings emphasize the benefits of CRA in fostering deeper understanding and skill development in mathematical problem solving.

This suggests that school administrators are encouraged to provide training on CRA implementation. Professional development programs may be conducted to help teachers effectively apply CRA-based strategies in the classroom. Additionally, they may also develop CRA-Aligned Assessments, such as rubric-based problem-solving assessments that measure students' ability to devise, execute, and evaluate solutions.

For future researchers, they are encouraged to explore the long-term effects of CRA. Further studies should investigate the long-term retention of problem-solving skills among students exposed to CRA. Future research can explore how CRA impacts learning in algebra, geometry, and statistics to assess its effectiveness across various mathematical domains. In addition, they may compare CRA with technology-based or inquiry-based learning strategies to determine the most effective approach for enhancing problem-solving skills.

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